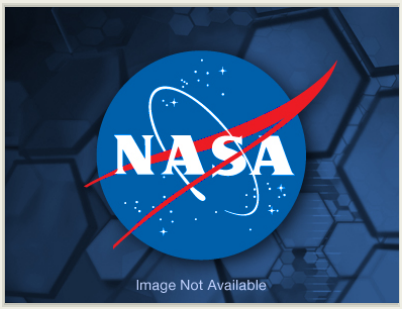
The Spectroscopic Terahertz Airborne Receiver for Far-InfraRed Exploration (STARFIRE): a Pathfinder for Next-Generation Extragalactic FIR Spectroscopy -- JPL Co-I

Completed Technology Project (2016 - 2021)

Project Introduction

This is the JPL co-I submission for the Spectroscopic Terahertz Airborne Receiver for Far-InfraRed Exploration (STARFIRE). Understanding the formation and evolution of galaxies is one of the foremost goals of astrophysics and cosmology today. The cosmic star formation rate has undergone a dramatic evolution of the course of the last seven billion years. Dust-obscured star forming galaxies (DSFGs) offer the perfect tracers of this evolution as they contain much of the star-forming activity. By their very nature, DSFGs are difficult to study and have, until recently, been poorly understood. A variety of unextincted diagnostic lines are present in the far-infrared (FIR) which can provide insight into the conditions of star formation, including the instantaneous star formation rate, the effect of AGN feedback on star formation, the mass function of the stars, and the spectrum of their ionizing radiation. Spectroscopy in the far-infrared is technically difficult but scientifically crucial. Stratospheric balloons offer a platform which can outperform current instrument sensitivities and are the only way to provide large-area, wide-bandwidth spatial/spectral mapping at short wavelengths. STARFIRE will provide a technological stepping stone to the future space-borne instrumentation such as the Far-IR Surveyor or a Probe mission. Key to this science is the development of a telescope using low-emissivity, high-throughput optics onto a dispersive spectrometer, and having high-sensitivity, large-format detector arrays. We propose an aggressive program of instrumentation development and experimental study called the Spectroscopic Terahertz Airborne Receiver for Far-InfraRed Exploration (STARFIRE), with the goal of demonstrating the key technical milestones necessary for balloon-borne FIR spectroscopy limited by the photon noise from the atmosphere. STARFIRE will address the two key technical issues necessary to achieve this: 1) Low-emissivity, high-throughput telescope and spectrometer optics 2) Background-limited detectors in large format arrays, scalable to >10,000 pixels We will do this by constructing an integral-field spectrometer from 240 - 420 microns coupled to a 2.5 meter low-emissivity carbon-fiber telescope. For the detectors, we will leverage the highly advanced development work of the Caltech / JPL group to develop and field kinetic-inductance detectors (KIDs). KIDs represent the most promising route to economical, large format submillimeter detector arrays. The development of the optics will utilized the capabilities of the Arizona Steward Observatory mirror lab and the unique expertise of our spectroscopic experts to create high throughput optics. Scientifically, we will 1) Obtain spectra of ~100 galaxies in the fine structure lines CII(158 micron) (0.5 < z < 1.5), OI(63 micron) and OIII(88 micron) (2 < z < 4), and establish their correlation with other galaxies via stacking 2) Demonstrate deep tomographic maps capable of detecting the aggregate shot-noise and clustering power spectra of CII from galaxies across the peak of cosmic star formation.



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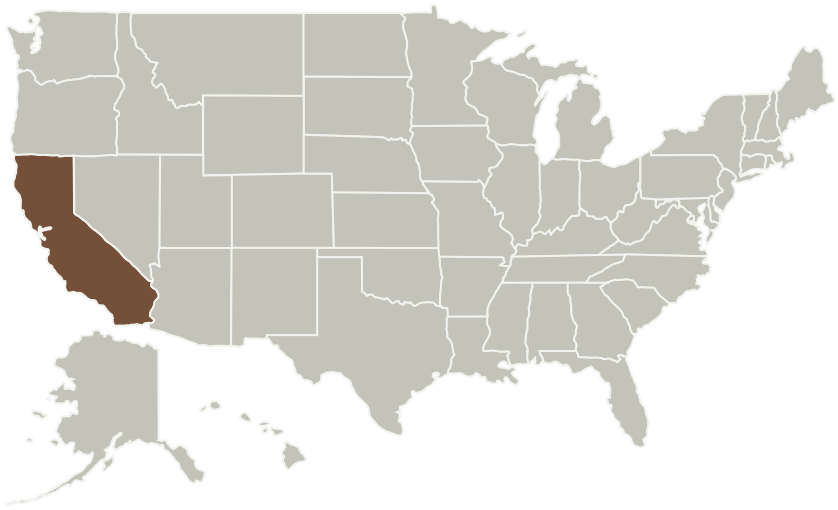
Anticipated Benefits

The Astrophysics Research and Analysis program (APRA) supports suborbital and suborbital-class investigations, development of detectors and supporting technology, laboratory astrophysics, and limited ground based observing. Basic research proposals in these areas are solicited for investigations that are relevant to NASA's programs in astronomy and astrophysics, including the entire range of photons, gravitational waves, and particle astrophysics. The emphasis of this solicitation is on technologies and investigations that advance NASA astrophysics missions and goals.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
California Institute of Technology(CalTech)	Supporting Organization	Academia	Pasadena, California

Primary U.S. Work Locations
California

Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

Responsible Program:

Astrophysics Research and Analysis

Project Management

Program Director:

Michael A Garcia

Program Manager:

Dominic J Benford

Principal Investigator:

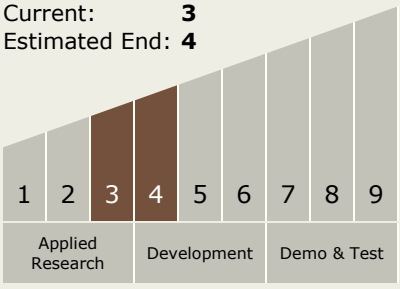
Charles M Bradford

Co-Investigators:

Steven Hailey-dunsheath
Carlos J Velazquez

Technology Maturity (TRL)

Start: **3**
Current: **3**
Estimated End: **4**



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Technology Areas

Primary:

- TX02 Flight Computing and Avionics
  - TX02.2 Avionics Systems and Subsystems
    - TX02.2.7 Data Reduction Hardware Systems

Target Destination

Outside the Solar System